APPENDIX C

TRACK (1.0): TRACK DESIGN AND EVALUATION FOR WORK PLANNING AND BUDGETING DESCRIPTION AND EXAMPLE

C-1. Introduction

a. The TRACK program is intended for the structural evaluation of existing track, or of a new design. TRACK is designed for lower speed railroads with light to moderate traffic volumes, as is the case at most military installations. It provides an evaluation of vertical track support for a given wheel load and was developed to serve two main purposes:

(1) To provide an estimate of the suitability of an existing track or new track design to handle its expected loading.

(2) To permit an initial look at the effects of changes in an existing track or new track design-either improvements or deterioration.

b. More specifically, the program is intended to help answer the following questions:

(1) Are there weaknesses in the existing track system? (2) If no weaknesses are apparent, how much deterioration can occur before weaknesses do appear? (How much "reserve capacity" is there?)

(3) If weaknesses are apparent, which track system components are deficient?

(4) How serious are the deficiencies?

(5) What improvements will eliminate the deficiencies?

c. Use of this program should be considered only a first step in checking the capability of existing track, a new design, or in examining rehabilitation alternatives. The program is not a substitute for railroad engineering expertise; it is 'one tool of several that should be used in any thorough examination of the track system and design or rehabilitation alternatives.

C-2. Screen Arrangement and Program Operation.

a. A sample main menu screen is show in figure C-1. The main menu is in the upper left. Choices 1 through 5 lead to a sequence of screens which ask questions about load and track characteristics. To use the program, select items 1 through 5 in succession and respond to the questions. All questions must be answered for results to be generated.

b. The questions require using the up or down ARROW keys to select from a list or typing an appropriate answer in the space provided. In either case, push the ENTER key afterward to input the information into the program. At any time, the user may back up to a previous question using the ESC (escape) key. One question in item 3 (Ties and Plates) requires using the map in figure C-2.

c. As items 1 through 5 are completed, the chosen input values for the equations are shown in the box on the right. Once items 1 through 5 are all complete, the program automatically performs the calculations and displays the results in the bottom box.

d. Main menu item 6 allows saving a trial case (all the selected answers, equation input values, and results).to a file, loading (retrieving) a previously saved trial case, or deleting a trial case. Item 7 will show a complete output report on the screen or send it to a printer. This report gives a listing of all the input describing the load and track characteristics for the trial case, as well as the analysis results. An example report is shown in figure C-3. Item 8 is chosen to exit the program.

e. The box to the right of the main menu shows the last input values that were used in solving the track analysis equations. (When the program is started, zero values automatically appear until the user provides input through choices 1 through 5 in the main menu.) f The bottom box shows the results from the last run. The first column of numbers are the calculated values, the second column shows suggested limits (for the type and condition of the track, as described), and the third column simply compares column 2 with column 1. Values less than 100% indicate adequate strength, with values over 100% indicating overload or overstress.

g. After changing information in any of the main menu items 1 through 5, the program automatically creates new input values of the track analysis equations, recalculates the equations, and returns to the main menu screen, which shows the revised input and results. Users may change one or all input values when re-running the track evaluation. While the program is active (on screen), all values not changed are taken from the last trial case.

Main Menu
1. Input for WHEEL LOADING
2. Input for RAIL
3. Input for TIES
4. Input for BALLAST
5. Input for SUBGRADE
6. Direct Input of Track Variables
7. Load, Save or Delete a Case
8. PRINT Results
9. Quit Program

Current Input Values and Results }

[Input Values for TIE2.TRK]

Rail Wt.	-	90.	lbs.
Rail I	-	38.7	in^4
Tie Spacing	-	22.0	in
Tie I	-	257.00	in^4
Tie E	-	1605615.	psi
Ballast dpth	-	12.0	in
Ballast E	-	34000.	psi.
Subgrade E	-	1890.	psi
Wheel load	-	31000.	lbs.

[Suggested Limits and Analysis Results]

Description	Stresses and Loads	Suggested Limits	% of Limit
Rail Bending Stress	13203 psi	26000 psi	51%
Tie Reaction	15186 lbs	52236 lbs	29%
Tie Bending Stress	1228 psi	1557 psi	79%
Ballast Surface Stress	43.2 psi	54.6 psi	79%
Subgrade Stress	8.94 psi	8.77 psi	102%

Figure C-1. Main Menu for TRACK (1.0).

C-3. Use.

a. For new (or completely rebuilt) track, the designer should select track components which give stresses and loads below the suggested limits. However, as the program provides only approximate values, changes (or differences) of less than 10% should be considered as not very significant. Different alternatives may be generated, with the final selection made by considering economics, material availability, operating requirements, etc.

b. When answers to questions about the track are not well known, designers should pick the nearest likely minimum and maximum values. If the results change significantly between the two answers, additional investigation should be done to determine the most appropriate choice. If no significant change occurs, no additional investigation is required.

c. For characterizing the subgrade, the program allows several options. When only the soil classification is known, both the screen and the output report will note this as not as reliable as the other methods. When possible, the other methods should be chosen, with responses based on accurate information.

C-4. Example.

a. The following example illustrates a typical application of the TRACK program and the type of evaluation that should accompany the results. In The example, it is as important to note the manner i which the program is used as it is to examine e numbers produced.

b. The DEH at Fort Example is told to start expecting regular traffic or fully loaded 140-ton flatcars at the installation. From inspection information and knowledge of the track, the following established:

(1) RAIL: 75 pound, in good condition with very little wear.

(2) TIES: The large majority are 6" thick and wide, in fair to good condition, with average pacing of 22". The most common defect (in the tie late area) is splits about 1 inch wide (through the whole depth of the tie).

(3) BALLAST: At the top, filling in between he ties, there is good, clean crushed rock, but this extends down only 6" below the bottom of the tie-which is what counts for load support.

(4) SUBGRADE: Medium-soft: acceptable, drainage is fair to good.

(5) WHEEL LOADS: 140-ton flatcars at 10 to 5 mph.

c. Figure C-3 shows the results of this initial case. If the 140-ton cars were to be regularly run over the existing track, ties, ballast, and subgrade would be significantly overstressed.

d. The DEH realizes that the 6" of real ballast under the track is insufficient, so a trial run is lade to add an additional 6" to the track. Table ’1 shows the results.

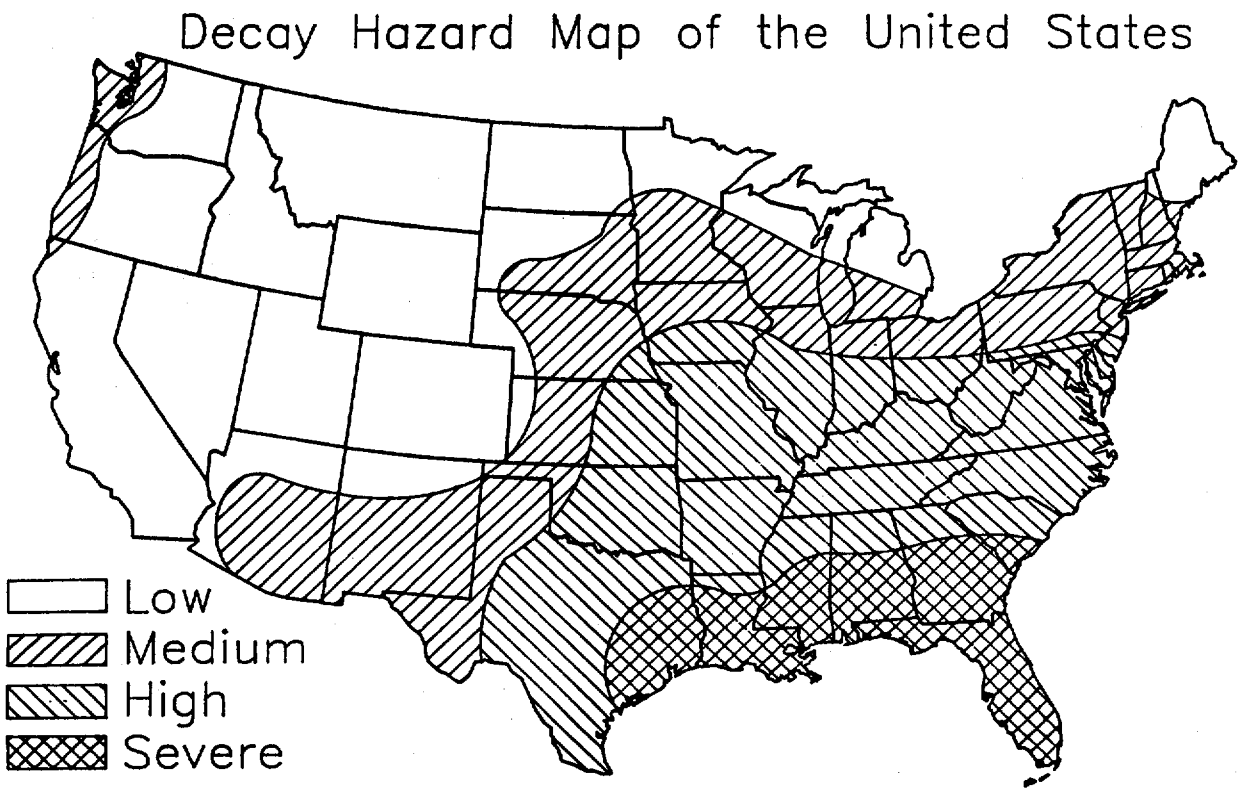

Figure C-2. Decay Hazard Map of the U.S.

Track Structural Evaluation Program Report 07-20-1994

Initial Case - Existing-Fort Example Track.
Description of Track Conditions:

Track Loading	
Most common heavy car	Flat, 140 T
Design wheel loading type	10 to 25 MPH
Design wheel load (lbs)	38750
Rail	
Rail weight (lbs/yd)	75
Rail moment of inertia (in^4)	23
Ties	
Tie moment of inertia (in^4)	135
Tie modulus of elasticity (psi)	1082648
Type of wood in ties	Hardwood
Nominal dimensions of tie (in)	6 x 8
Tie spacing (in)	22
Dimensions of tie plate (in)	11 x 7.5
Tie Age (years)	15
Decay hazard	medium
Tie Moisture state	dry
Most important tie defect	split tie
Split width (in)	1
Ballast	
Ballast Modulus of elasticity (psi)	37500
Ballast depth (in)	12
Majority of ballast made up of.	> 50% larger than 1/2 inch
Ballast moisture condition	dry
Most common stone sizes	3/4" to 1 1/2"
Percent fines	< 10%
Shape of stones	angular
***Subgrade* * *	
Subgrade modulus of elasticity (psi)	3000
Bearing Capacity information source	Program
Classification system used	DIRECT

Track Stresses and Suggested Limits:

Description	Stresses and Loads	Suggested	Limits % of Limit
Rail Bending Stress	17800 psi	25000 psi	71%
Tie Reaction	20500 lbs	12600 lbs	162%
Tie Bending Stress	1580 psi	1050 psi	151%
Ballast Surface Stress	89 psi	61 psi	147%
Subgrade Stress	15 psi	15 psi	100%

Figure C-3. Report from TRACK (1.O).

Table C-1. Add 6" Ballast To Track.

	Stresses and Loads	Suggested Limits	% of Limits
Rail Bending Stress	17,800 psi	25,000 psi	71
Tie Reaction	20,500 lbs	12,600 lbs	162
Tie Bending Stress	1,580 psi	1,050 psi	151
Ballast Surface Stress	89 psi	61 psi	147
Subgrade Surface Stress	15 psi	15 psi	100

f. The results show that adding 6" of ballast does substantially reduce the subgrade stress, putting it at the allowable limit. However, ties and ballast are still overstressed, with tie bending stress and ballast surface stress slightly increasing (due to the stiffer ballast section of 12"). (Note: As the track characteristics are changed, the calculated stresses and loads and the suggested limits are likely to change. This behavior is a good illustration of the complex interaction of the track system components.)

g. Since the desired reduction in subgrade stress has been achieved by adding the 6" of ballast, the DEH decides to keep that change, at least temporarily, and add another improvement to see if tie and ballast stresses can be reduced. The DEH knows that 75 pound rail is very light, by commercial standards, so a trial is made to replace it with 115 pound rail-the lighter standard commercial rail. (Tie plate size will also increase to accommodate the larger rail.) Table C-2 shows the results.

Table C-2. Add 6" Ballast and Install 115 lb Rail.

	Stresses and Loads	Suggested Limits %	of Limit
Rail Bending Stress	12,300 psi	32,000 psi	38
Tie Reaction	17,600 lbs	14,200 lbs	124
Tie Bending Stress	1,380 psi	1,050 psi	131
Ballast Surface Stress	75 psi	61 psi	123
Subgrade Surface Stress	15 psi	15 psi	100

h. Replacing the 75 lb rail with 115 lb rail has reduced tie and ballast stress, but they are still too high. As the DEH also notes that rail replacement is a very expensive action, another alternative is considered.

i. In the existing track, nearly all the ties are 6" x 8" in cross section, while standard commercial main line ties are 7" x 9" in cross section. A trial is then made keeping the existing 75-lb rail (and the proposed 6" additional ballast), but upgrading the ties to the larger cross section. Table C-3 shows the results.

Table C-3. Add 6" Ballast and Install 7" x 9" Ties.

	Stresses and Loads	Suggested Limits	% of Limit
Rail Bending Stress	17,800 psi	25,000 psi	71
Tie Reaction	20,500 lbs	14,200 lbs	87
Tie Bending Stress	1,470 psi	1,050 psi	106
Ballast Surface Stress	66 psi	61 psi .	109
Subgrade Surface Stress	13 psi	15 psi	89

j. While tie bending and ballast surface stresses are still slightly over the suggested limits, table C-3 shows that installing 7" x 9" ties (instead of replacing the rail) has provided a more effective structural improvement to the track.

k. As a result of this analysis, the DEH decides to see about fitting the tie/ballast combination into the budget. This appears to be a good, cost-effective choice since, from a structural improvement perspective, it will accomplish more than the rail/ballast combination at much less expense.

l. In this case, though, even the tie/ballast combination turns out to be more than the current budget will allow, so the DEH considers the following: add the 6 inches of ballast this year, and as future budgets permit, begin replacing deteriorated ties with 7" x 9' ties. Though not obtainable immediately, over time this approach would appear to provide the kind of track needed to properly support the 140-ton flatcars. Further investigation into other factors and costs will be done before a final choice is made.

m. The example above was intended to demonstrate that with appropriate input to the TRACK program, and by knowing the relative costs of basic track work, the program can be used to indicate good, cost-effective alternatives for producing a track system with the required structural capability.